

Centerline Slot Implementation

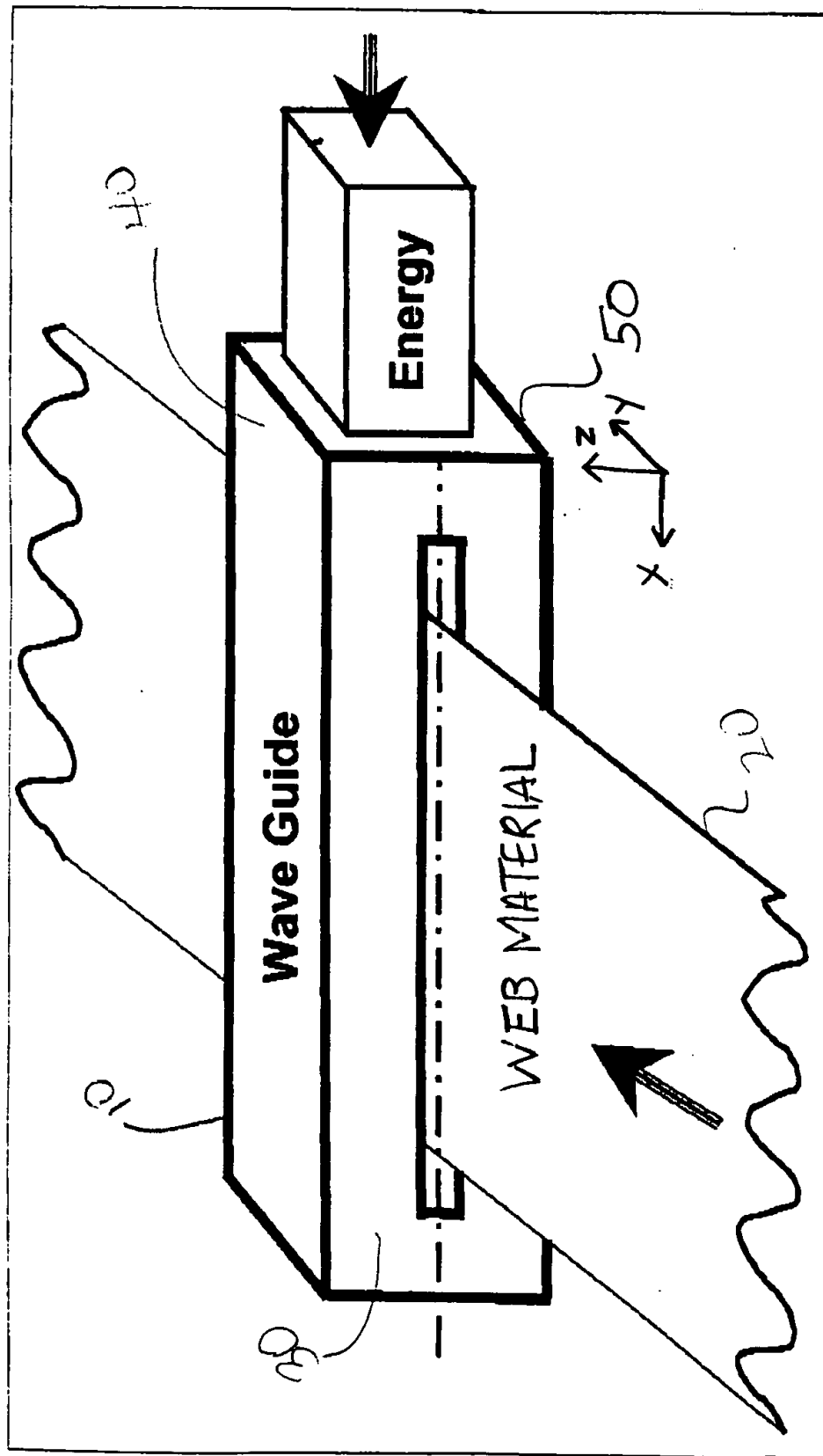


Fig. 1 PRIOR ART

Non-Centerline Slot

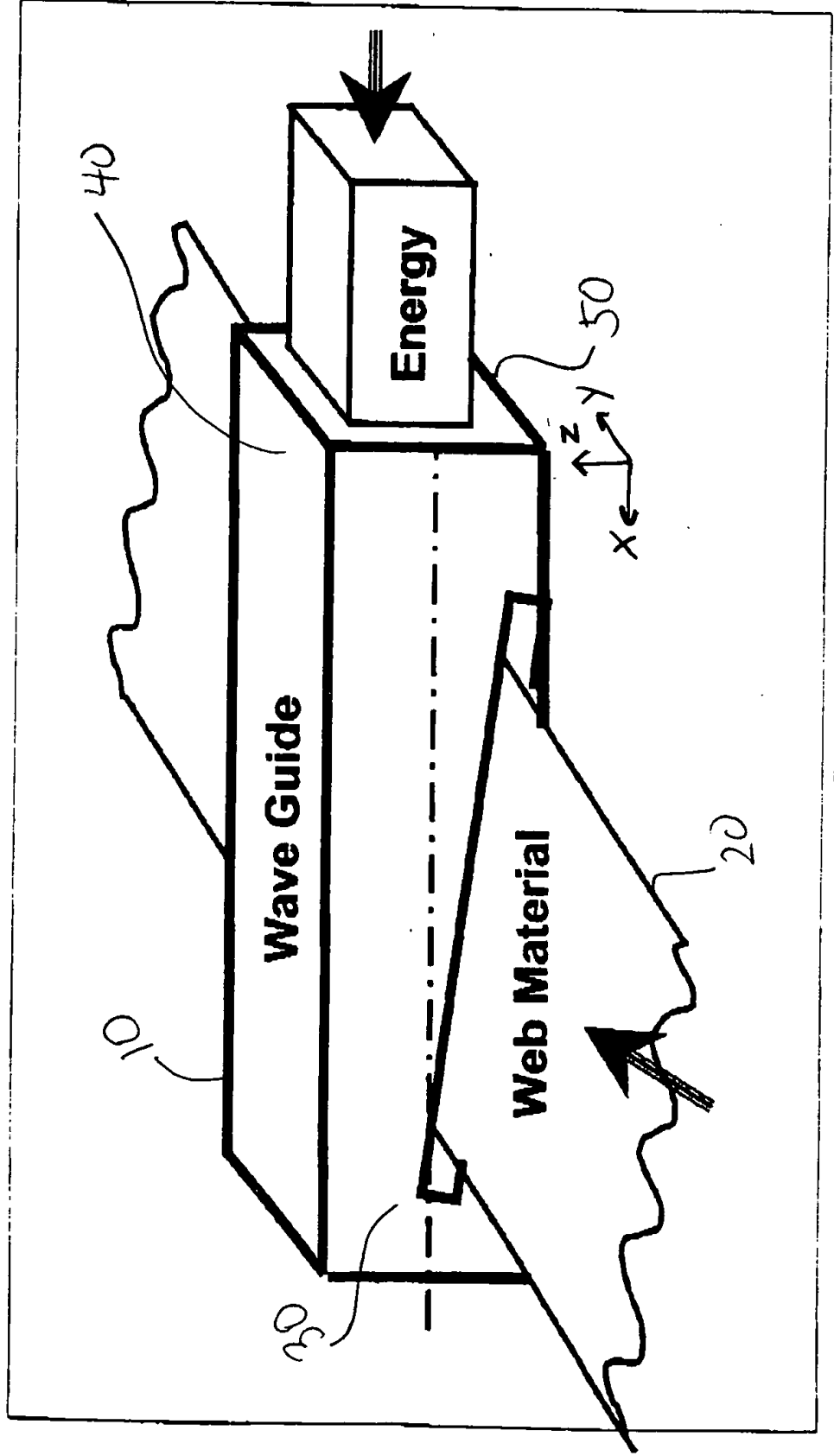
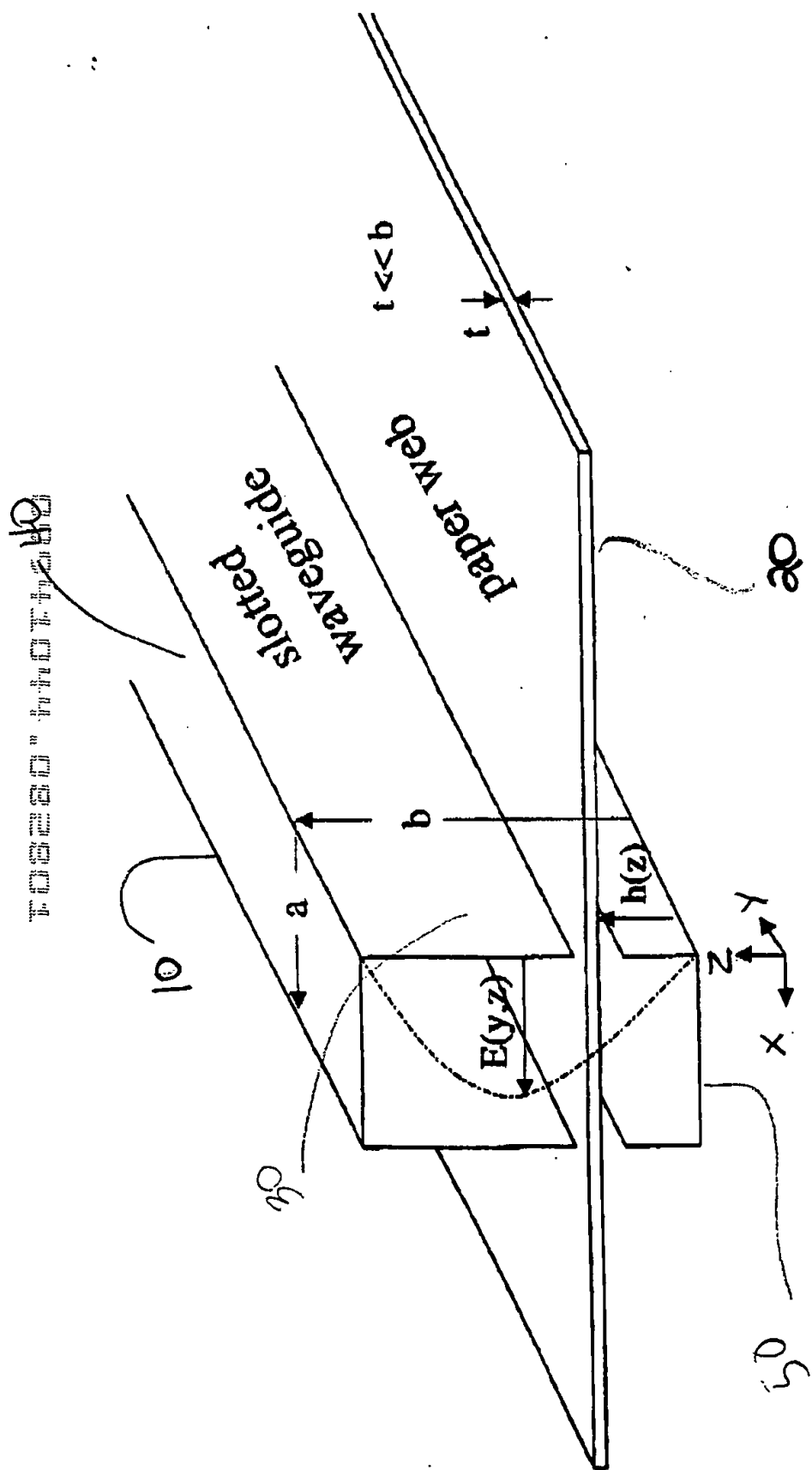
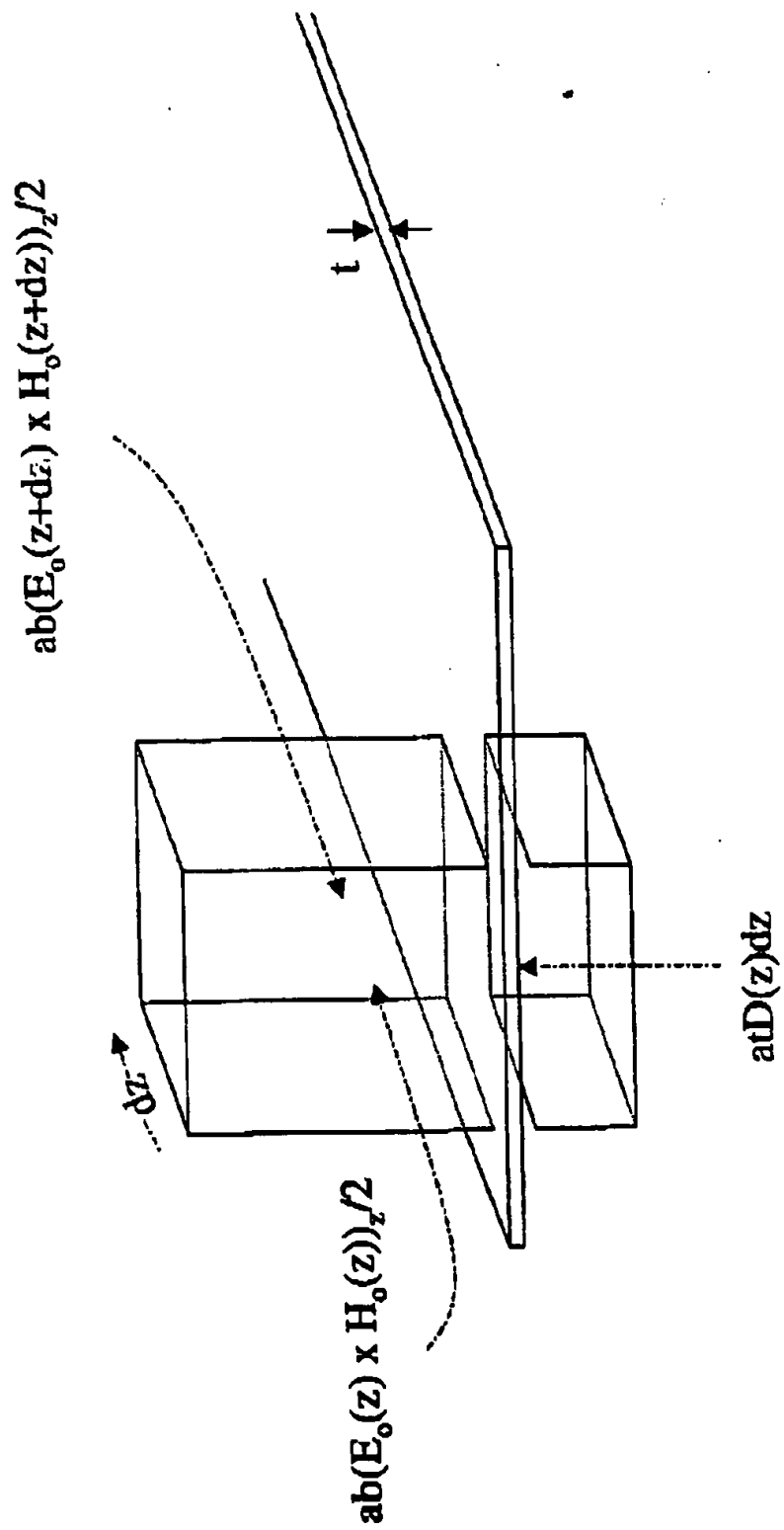


Fig. 2. PRIOR ART



Parameters for Paper Drying in a Waveguide

Figure 3



Schematic for energy balance on an infinitesimal guide section

Figure 4

Effect of using a linear slot profile

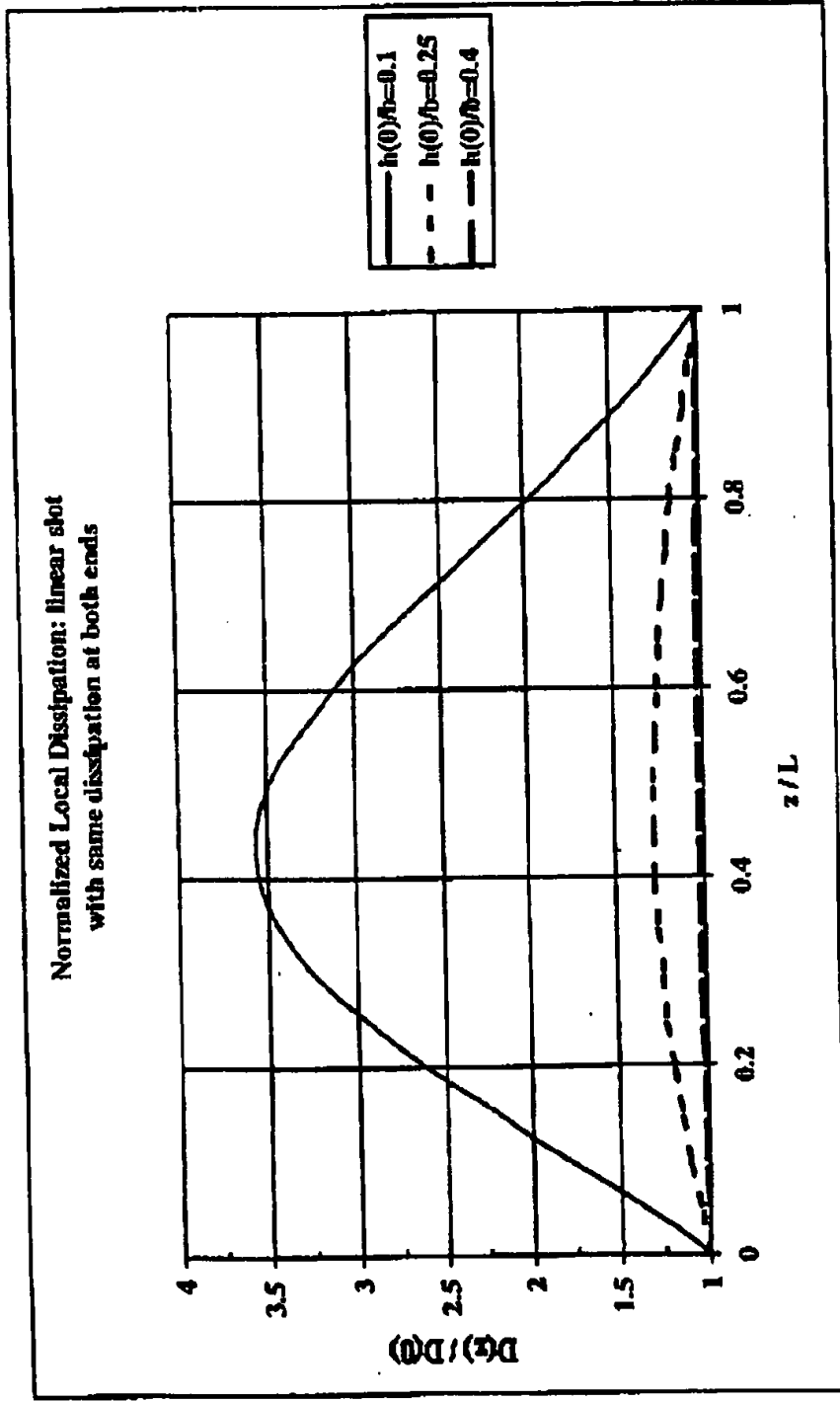
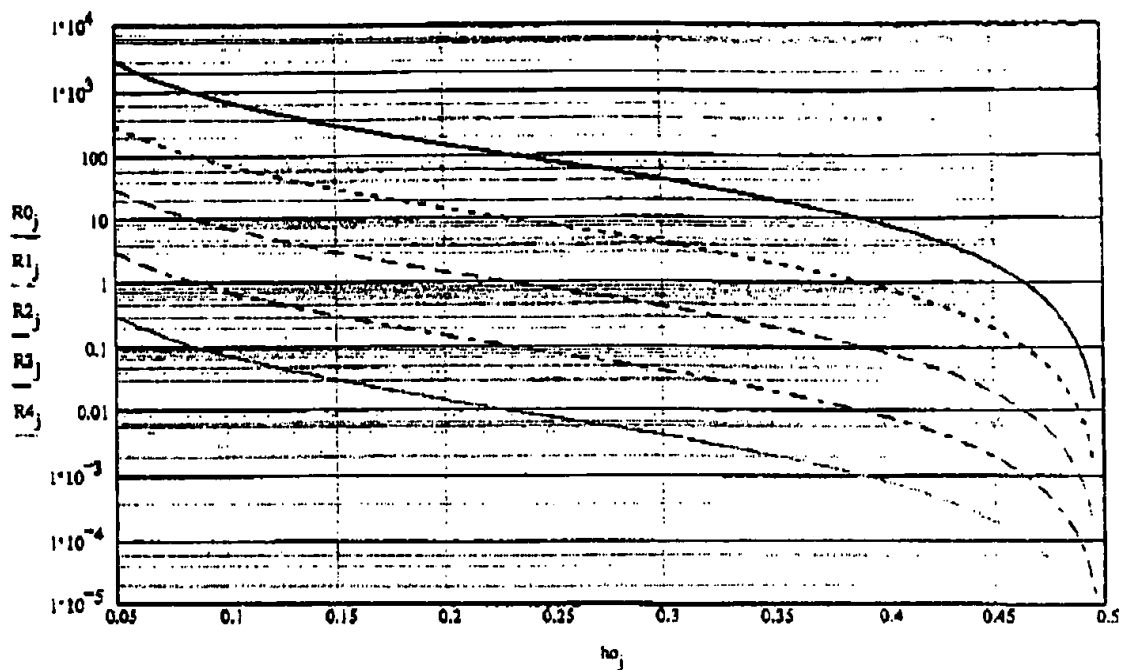


Figure 5

Linear Slot Dissipation Profile as a Function of Starting Slot Height



These are plots of the range of curved-slot-compensated waveguide as a function of h_o/b , the ratio of the starting slot height to the guide breadth. Curves are drawn for different values of $\epsilon \cdot t$ in meters. The values of $\epsilon \cdot t$ plotted are listed below. The curves drop to lower values as $\epsilon \cdot t$ increases

Figure 6

$b = 0.072$ guide breadth in m

$f = 2.45 \cdot 10^9$ frequency in Hz

$\sin(\pi \cdot \min)^2 = 0.024$

$$\epsilon t = \begin{bmatrix} 5 \cdot 10^{-6} \\ 5 \cdot 10^{-5} \\ 5 \cdot 10^{-4} \\ 5 \cdot 10^{-3} \\ 0.05 \end{bmatrix}$$

Now calculate the shape of a slot curve for a given $\epsilon''t$ and h/b

$\epsilon''t := 10^{-4}$ enter web imaginary dielectric constant times thickness in meters

$N := 1000$ enter number of data points in a slot curve plot

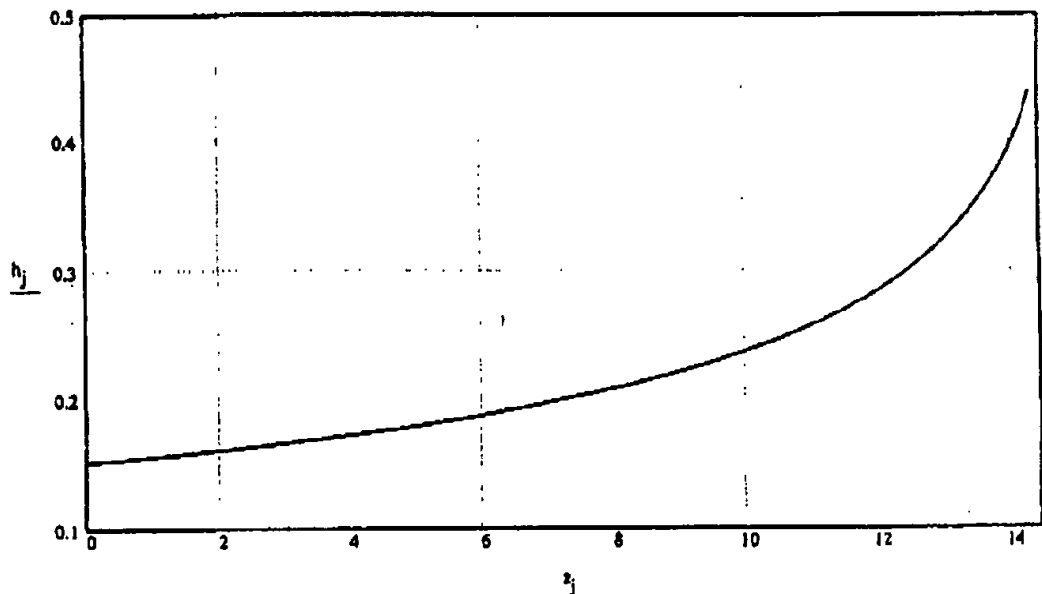
$j := 0..N-1$ set up iteration parameter for range plots

$h_{min} := .15$ enter starting ratio of h/b

$$z_{max} := \frac{b \cdot \left(\frac{1}{\sin(\pi \cdot h_{min})^2} - 1 \right)}{2 \cdot \omega \cdot Z_0 \cdot \epsilon''t} \quad \text{calculate maximum value of compensated } z$$

$$z_j := .99 \cdot z_{max} \cdot \frac{j}{N-1} \quad \text{generate values for slot height plots}$$

$$h_j := \left(\frac{1}{\pi} \right) \cdot \arcsin \left[\left(\frac{1}{\sin(\pi \cdot h_{min})^2} - 2 \cdot \omega \cdot Z_0 \cdot \frac{\epsilon''t}{b} \cdot z_j \right)^{\frac{1}{2}} \right] \quad \text{calculate slot height values normalized to } b \text{ as a function of } z$$



This is a plot of height of the slot divided by the guide breadth as a function of guide length in meters

Figure 7

$\epsilon''t = 1 \cdot 10^{-4}$ web imaginary dielectric constant times thickness (m)

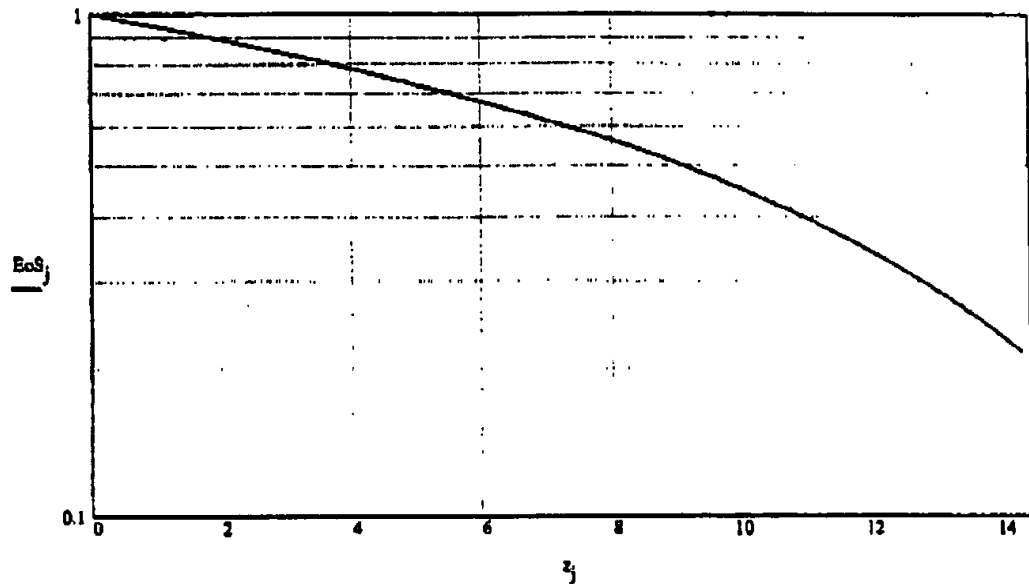
$h_{min} = 0.15$ initial h/b

$z_{max} = 14.443$ range of compensation in meters

Calculate the ratio of the E field intensity at the guide center to its initial value as a function of z for the same parameters as in the slot shape curve just above.

$$EoS_j := \left(1 - 2 \cdot \omega \cdot Z \cdot \frac{\epsilon_{ri}}{b} \cdot z_j \cdot \sin(\pi \cdot h_{omin})^2 \right)$$

calculate the ratio of Eo squared to Eoo squared as a function of z



This is a plot of the relative center guide field intensity versus guide length for an IMS optimum compensated slotted waveguide. The z axis is in meter and y axis is the intensity is ratioed to its value at z=0.

Figure 8

$$\epsilon_{ri} = 1 \cdot 10^{-4}$$

web imaginary dielectric
constant times thickness (m)

$$h_{omin} = 0.15$$

initial h/b

$$z_{max} = 14.443$$

range of compensation in meters

$M := 4$ enter number of web runs

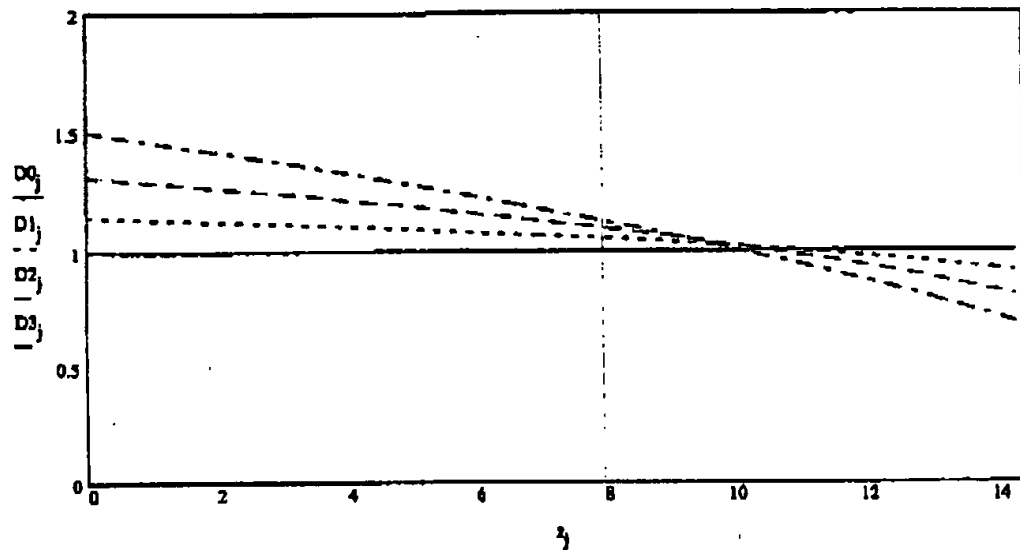
$R := 1.5$ enter maximum ratio of ert operation to ert designed

$m := 0..M - 1$ iteration parameter

$r_m := R^{\frac{m}{M-1}}$ calculate the values of the ratio of the actual ert to the designed ert

$$D0_j := r_0 \cdot \left(1 - 2 \cdot \omega \cdot Z \cdot \epsilon_0 \cdot \frac{ert}{b} \cdot z_j \cdot \sin(\pi \cdot h_{omin})^2 \right)^{r_0-1} \quad D1_j := r_1 \cdot \left(1 - 2 \cdot \omega \cdot Z \cdot \epsilon_0 \cdot \frac{ert}{b} \cdot z_j \cdot \sin(\pi \cdot h_{omin})^2 \right)^{r_1-1}$$

$$D2_j := r_2 \cdot \left(1 - 2 \cdot \omega \cdot Z \cdot \epsilon_0 \cdot \frac{ert}{b} \cdot z_j \cdot \sin(\pi \cdot h_{omin})^2 \right)^{r_2-1} \quad D3_j := r_3 \cdot \left(1 - 2 \cdot \omega \cdot Z \cdot \epsilon_0 \cdot \frac{ert}{b} \cdot z_j \cdot \sin(\pi \cdot h_{omin})^2 \right)^{r_3-1}$$



These are plots of the web heat dissipation relative to the heat dissipation at $z=0$ in the designed waveguide as a function of waveguide length in meters. Different curves have different ratios of ert operating to ert designed. The actual ratios are listed below as r

Figure 9

$ert = 1 \cdot 10^{-4}$ designed web imaginary dielectric constant times thickness (m)

$z_{max} = 14.443$ range of compensation in meters

$h_{omin} = 0.15$ initial h/b

$$r = \begin{bmatrix} 1 \\ 1.145 \\ 1.31 \\ 1.5 \end{bmatrix}$$

Two Serpentine Microwave Applicator Configurations: (a) Short at Termination End; (b) Dummy Load at Termination End.

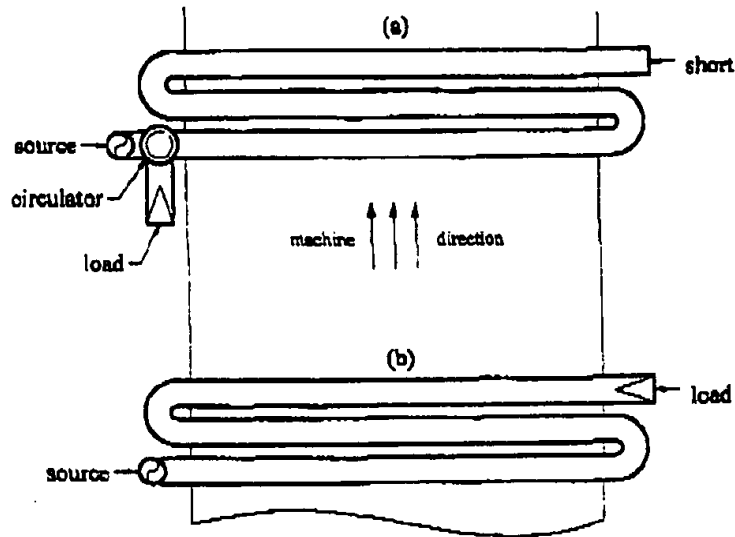


FIGURE 10

Definition of Slot (and Paper)

Location within the Waveguide. The cross-machine coordinate is z and $h(z)$ is the local elevation of the slot above the bottom of the waveguide. The overall active cross-machine length is L .

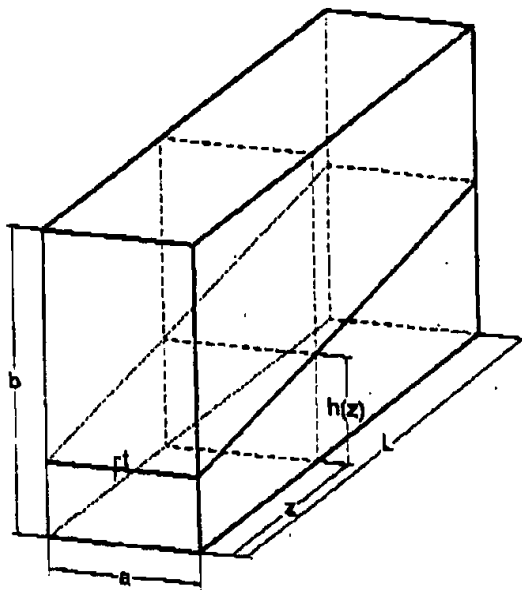
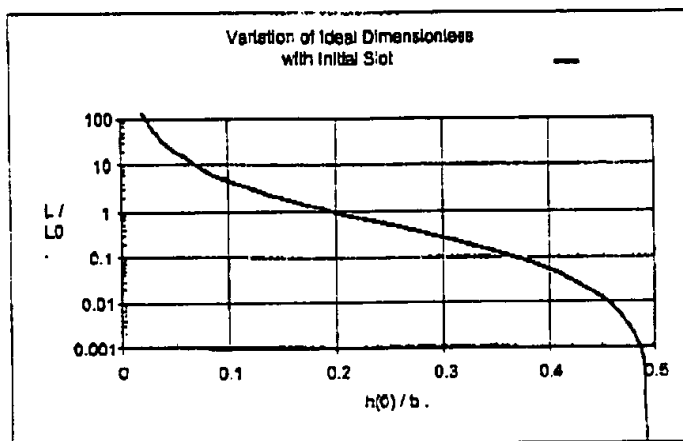


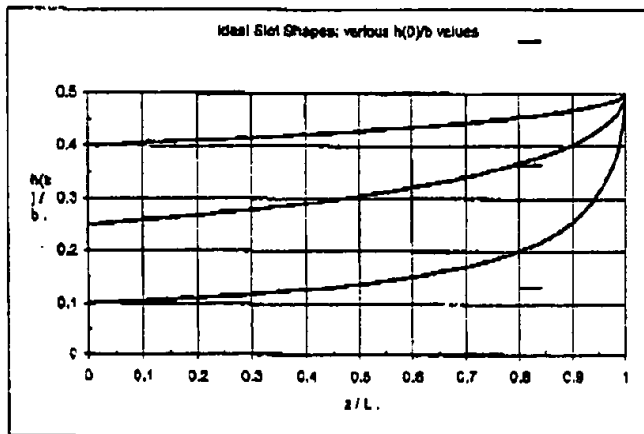
FIGURE 11



Ideal Dimensionless Length vs. Initial Slot Height.

FIGURE 12

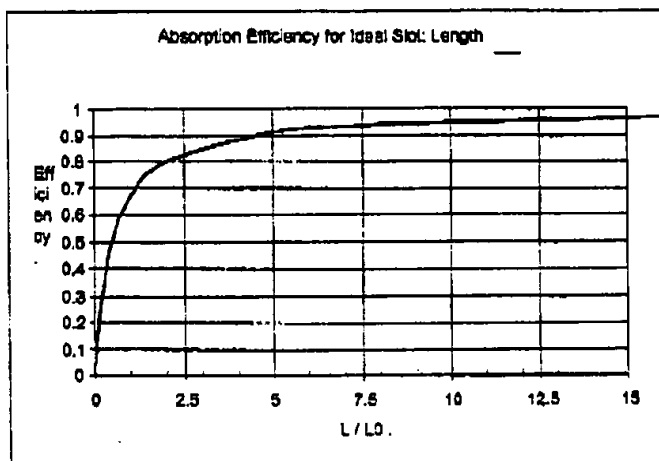
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Ideal Slot Shapes for $h(0)/b = 0.1, 0.25, 0.4$.

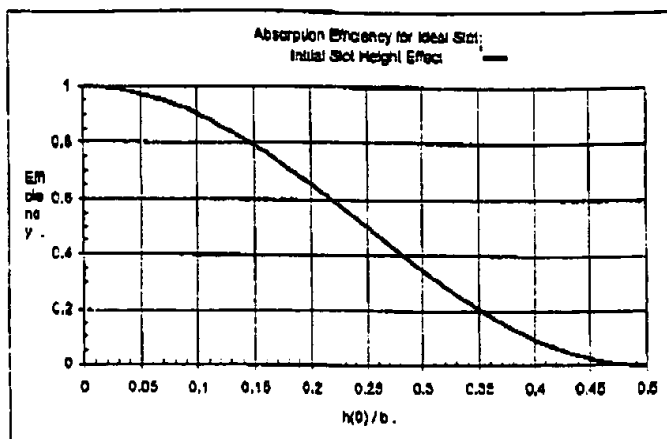
FIGURE 13

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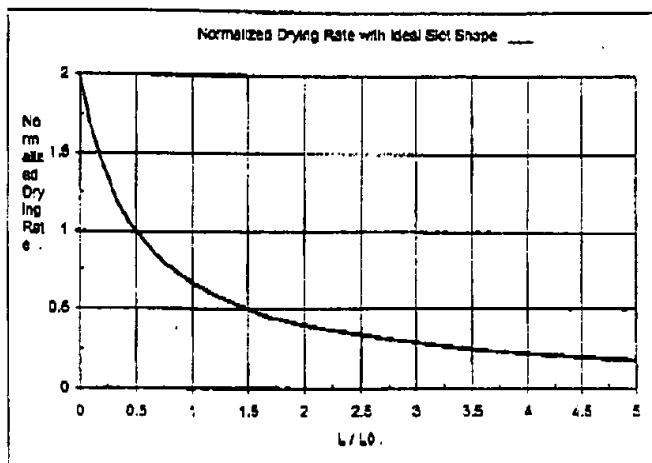
Efficiency vs. Ideal Dimensionless Length.

FIGURE 14



Efficiency (at Ideal Length) vs. Initial Height.

FIGURE 15



Normalized Drying Rate for Ideal Length.

FIGURE 16

The slot height profile, $h(z)$, which gives uniform drying depends on the paper basis weight and its moisture content, $\epsilon_r t$.

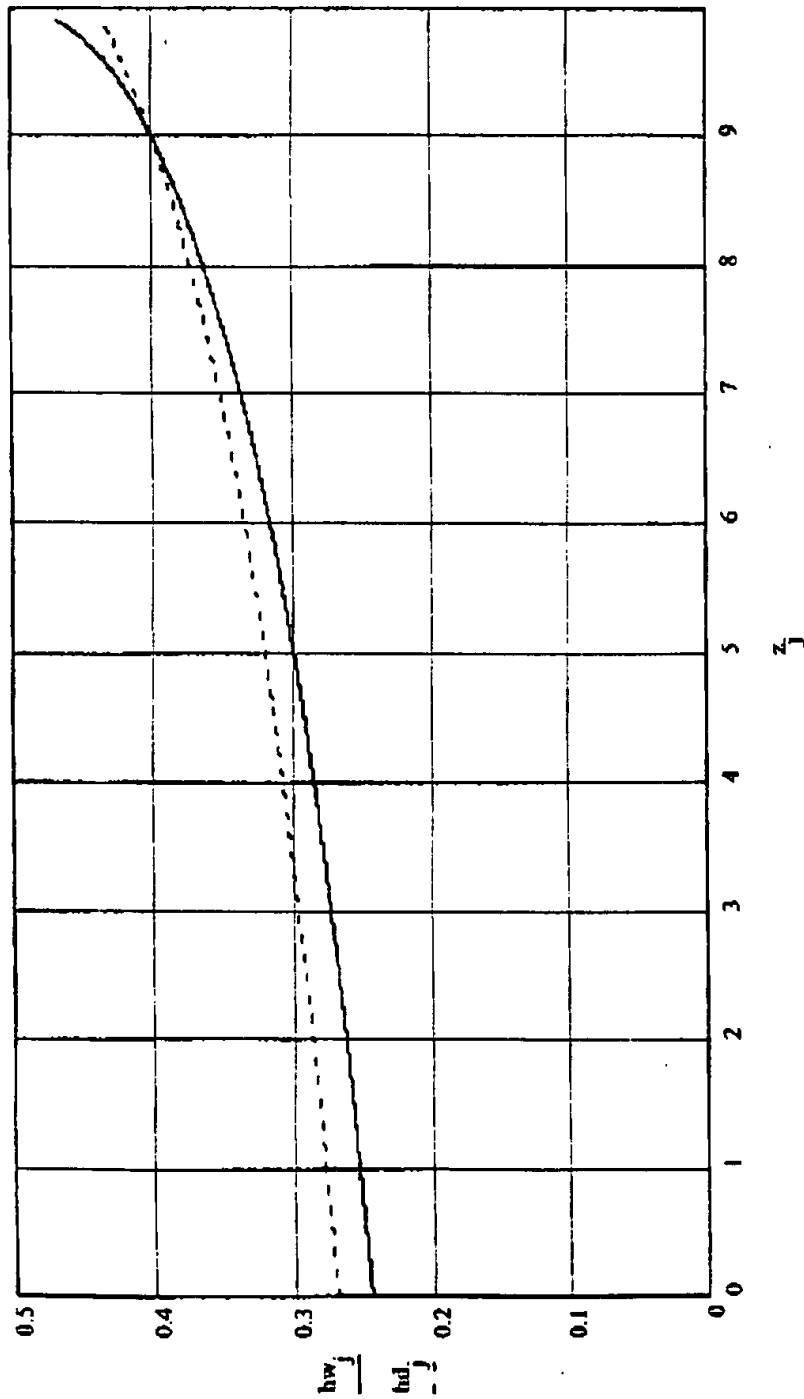
The optimal slot profile is

$$h(z) = (b/\pi)\sin^{-1}[(1/\sin^2(\pi h_o/b) - 2Z\omega\epsilon_o\epsilon_r t z/b)^{-1/2}]$$

where h_o represents the slot height at the source side of the web and z is the distance along the waveguide (CD).

Fig. 17

Optimal Slot Profiles



Plots of the optimal slot height divided by the waveguide height as a function of distance in meters from a microwave source at 2.45 GHz in an S-band waveguide. The solid line is designed for a 200 g/m² board at 10% moisture, whereas the dotted line is for 7% moisture.

Fig. 18

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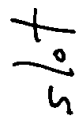
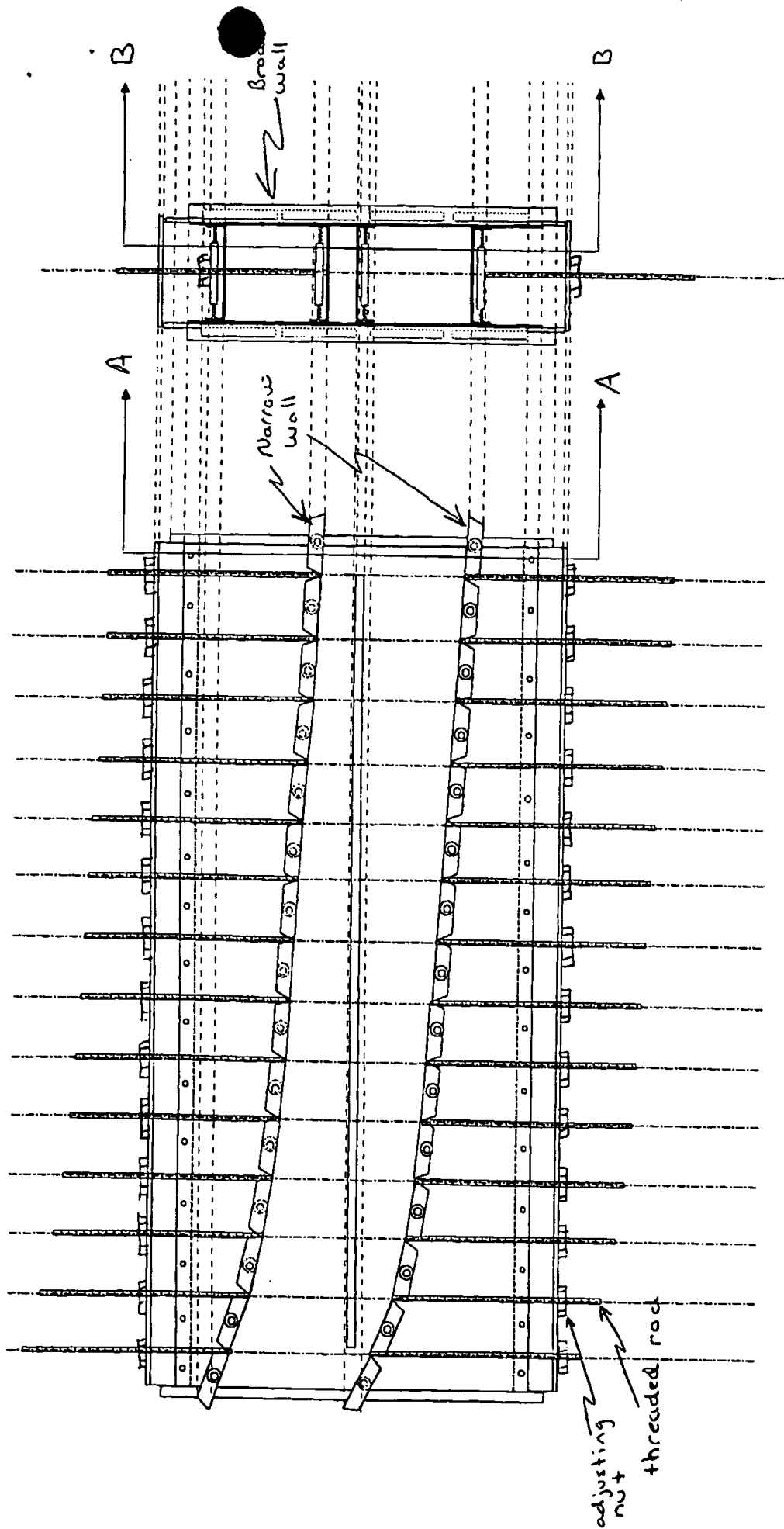


FIGURE 19

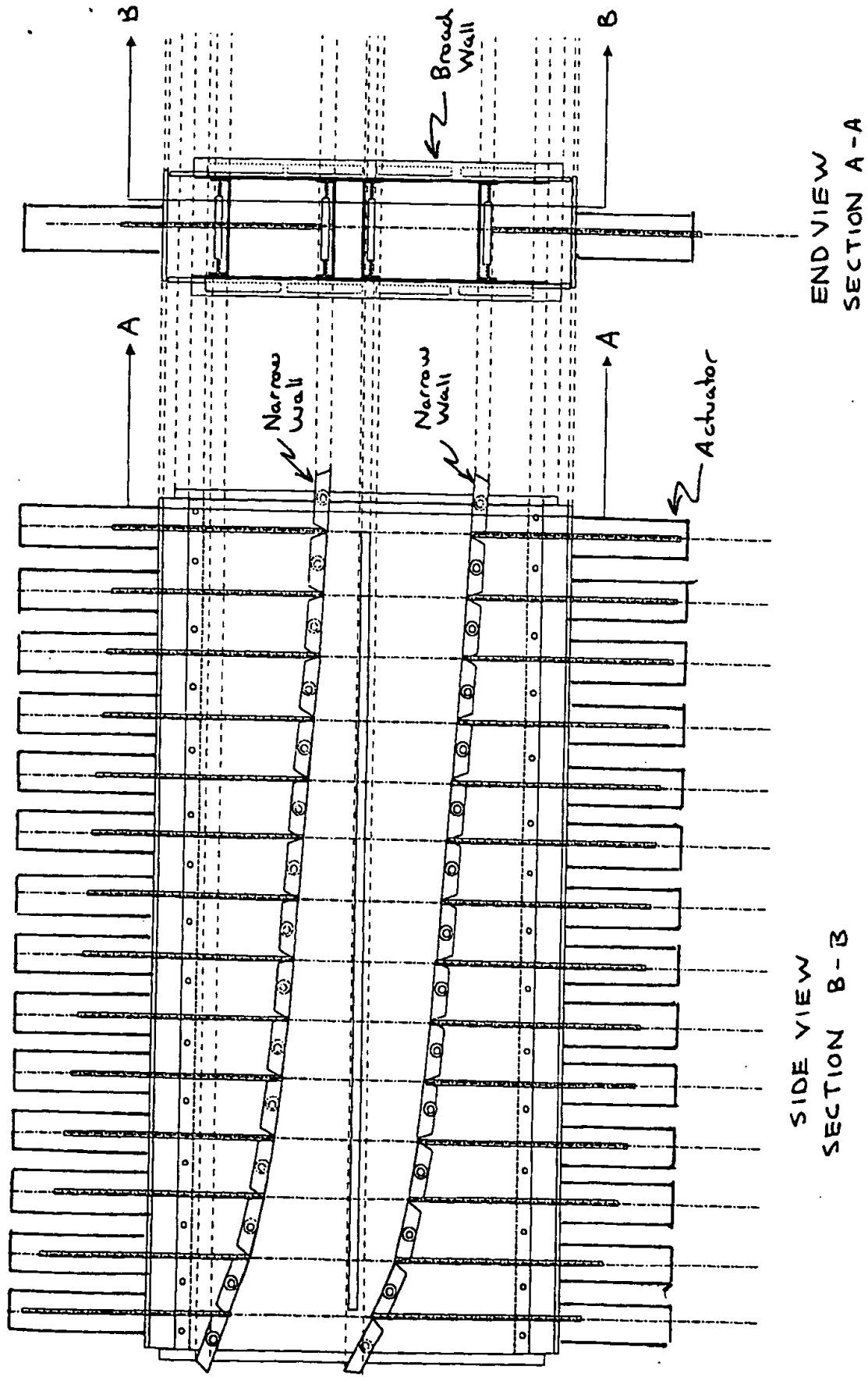


SIDE VIEW - SECTION B-B

END VIEW
SECTION A-A

Manually Adjusted Variable Waveguide

Fig. 20



Automatically Adjusted Variable Waveguide